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DEPARTMENT OF AGRICULTURE, FIJI.

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EDITORIAL.

DURING the past year attention has been largely focused on the banana industry, which has experienced changes likely to have far-reaching effects. The trial shipments to Vancouver, the introduction of the quota system for supplies to New Zealand, the reduction of the heavy Customs duty for a limited quantity of fruit imported into Australia from Fiji, and the change-over to a type of case new to the Fiji shippers, have provided all interested in the industry in Fiji with much food for thought and incentive to action. The appointment of a Special Committee on the occasion of the July Session of Legislative Council by His Excellency the Officer Administering the Government is a useful step which should lead to a survey of the industry as it is to-day and to recommendations of service to producers and exporters. Though the Agricultural Department has devoted as much of its energies to investigation of the problems of the banana industry as its widely varied duties and limited resources permit, there is a profitable field awaiting research and exploration, which can now receive more attention since the arrival of an officer competent to inquire into plant disease problems. The public-spirited offer of the Hon. J. P. Bayly, M.L.C., of 50 acres of land for five years at a nominal rental will enable progress to be made with the commercial exploration of the Vancouver market, said to be capable now of taking 2,000 to 3,000 stems of bananas monthly from Fiji, and later of offering remunerative prices for 10,000 to 12,000 stems monthly.

Marketing conditions in New Zealand, and in Sydney and Melbourne, were carefully examined by the writer during the period December 23rd to May 5th. The principal towns in both Islands of New Zealand were visited, and contact renewed with official and commercial interests in Wellington and Auckland. Two visits were paid to Sydney and Melbourne, when a large number of Government officers and members of importing firms were met. The information thus obtained by personal inquiry has as far as possible been recorded, and has enabled plans for the better control of production and export to be made in the light of conditions obtaining in the consuming countries.

It is satisfactory to know that the Thrips introduced for the attempted control of *Clidemia hirta* (Köster's Curse) continues to exercise severe attack on the weed in most districts of the Colony. Seasonal variation in the luxuriousness of the growth of the weed is naturally to be expected, but despite the very wet season of early 1933, recent observations have disclosed that in many places the weed has completely disappeared, while in others it is giving way to other growth. The danger that the growth thus replacing

Köster's Curse may prove to be more objectionable has been pointed out by Mr. Simmonds, the Government Entomologist. He has also called attention to the risk of reinfestation of land by over-stocking. It may now reasonably be claimed that the " curse " in most places in the Colony is capable of a simple and cheap method of control. The cutting down of the weed in the first instance is of considerable advantage because the young growth which follows is immediately attacked by the Thrips and given such a check that it is choked out by various other plants.

The appearance of a new agricultural publication entitled the *Agricultural Gazette* of the B.S.I.P. under the editorship of Major F. Hewitt and issued under the auspices of the Official Agricultural Committee of the Protectorate is welcomed. Members of the staff of the Fiji Department greatly appreciate the cordial remarks made in the first issue in reference to co-operation in connection with agricultural affairs in the Solomon Islands. One comes to realise to an ever greater extent the vital necessity of close co-operation in agricultural affairs amongst the Departments responsible for production and plant protection in the isolated island communities of the Western Pacific, and it is pleasing to know that although the views of Fiji do not always meet with approval in the Solomons the spirit with which those views are offered is appreciated. The Fiji *Agricultural Journal* wishes the *Agricultural Gazette* of the B.S.I.P. a long, successful, and useful life.

This issue of the *Agricultural Journal* is the last that the present editor will have the pleasure of preparing for the press. In fact, it will not be possible for him to see it through to publication owing to his departure from the Colony on transfer to the service of Jamaica on the 8th August, 1933. The opportunity is taken of expressing sincere thanks to all those contributors to the pages of the *Journal* during the past four years and to contemporary *Journals* which have permitted their articles to be drawn upon for publication. The association of the editor with Fiji agricultural affairs in many capacities has proved most interesting and instructive. Whatever progress may have been made since one assumed office is attributed to the cordial relations which have obtained amongst the staff of the department and their assiduity and co-operation in the discharge of the duties of the department.

The Agricultural Convention formed in 1931 cannot be said to have achieved a great deal so far, but the hope is expressed that the participating Associations, particularly those in country districts, will recognise the advantage of having a central body to represent and support their views and will make full use of that organization whenever it becomes necessary for them to put forward to the Government any matters concerning agricultural welfare. The four Conferences during the period 1930–1933 have, one ventures to hope, proved of real value in that they have enabled various aspects of departmental working and general agricultural production to be brought to the public notice at open meetings and have, at the same time, afforded opportunities to gentlemen engaged in commerce and agriculture to express publicly their views to representative audiences.

In conclusion the editor bids farewell to the readers of the *Agricultural Journal* and records his best wishes for the future progress of the Colony of Fiji and of the agricultural community in particular.

LIMITS TO PRACTICAL BIOLOGICAL CONTROL.

By H. W. Simmonds, F.E.S., Government Entomologist.

The success which has been attained in Fiji, Hawaii and Australia in the control of certain insect and weed pests by biological agencies has raised a feeling of optimism that all pests and weeds can be held in check by such agencies and it seems advisable to point out some of the limitations of the method, so that false hopes may not be raised. Where the method can be applied there is no doubt that it is ideal and it is the great successes which have been attained that have raised the danger of engendering a feeling that other methods, such as cultural and chemical, will not be required in future.

It will be well to point out at once that in the older densely populated portions of the world cultivation, hand picking of pests and rotation of crops still play the big part in the control of unwanted insects and weeds. What then are the factors rendering the use of biological methods possible or limiting their application ?

2. *Ecological.*—When large areas of jungle are cleared and land previously shaded by big trees is exposed to the sun such land is not as a rule exclusively occupied by the new crop, but is invaded by a number of local or exotic forms of life which could not exist under forest conditions. Some of these, the plant forms, compete with the crop which it is proposed to raise, whilst others, the insect portion, may turn their attention to feeding directly upon such crop. Where such weeds or insects are indigenous, the fact that they are able to seize upon the new environment to the extent of interfering with the new crop indicates, in their case, an absence of efficient biological control.

Where the pest is exotic, the fact that it has become a pest proves that the general ecological conditions are favourable.

It is seldom that use can be made of local parasites in biological control, since the efficiency of such parasites cannot, as a rule, be permanently increased. An exception to this would be where a parasite was itself checked by an agency which it was found possible to reduce.

3. *Successful biological control.*—Successful biological control has in all cases hitherto been achieved when it has been possible to introduce an exotic natural enemy into a new country without some of its own limiting factors in its original home, and it is important to consider how such an introduction is likely to work.

4. If the new introduction is highly specialised to its host its only limitation, in the absence of natural enemies, is the availability of its food. This may be limited, not by the numbers of its host, but by difficulty of reaching it. All insects which live internally come within this category. This difficulty has been greatly increased by the production by man of fruits of a more luscious type than their wild progenitors in which certain insects are able to exist beyond the reach of those parasites which normally checked their numbers.

If, however, the new introduction is against a host which lives fully exposed to its attacks it may rapidly increase in numbers and for a time almost exterminate its host. Such abnormal control must, however, in a highly specialised parasite, bring about the destruction of itself and lead to the reappearance of its host and incidentally great disappointment to the planter. It will, however, after a while be followed by another increase of the parasite until a moving balance will be effected in which just sufficient

of the host survives to maintain both itself and parasite over a number of years. This is the best condition which is likely to be attained in the biological control of a noxious plant.

Where the new introduction is not so highly specialised, but is able to find alternative food to that which it was introduced to control, it may show such a preference for one food as completely to control this or even exterminate it. Such has been the case with *Levuana*.

5. *Climatic.*—Where an exotic insect or plant has beecome a major pest it may be that it has a wider degree of climatic tolerance than any of its natural enemies in its own home and such tolerance might greatly inhibit efforts to control it. In introducing the thrips, *Liothrips urichi* into Fiji it was found that this insect was able to survive freezing for three weeks, when in the pupal stage. It is extremely unlikely that most of its natural enemies in Central America would tolerate such cold, so that this insect would be able to survive climatic conditions which would probably greatly limit its natural enemies. The same will apply in the case of humidity, the tolerance of host and parasite or predator may not be the same and this may prove a big factor in bringing about or preventing successful biological control.

6. *General pressure and adaptability.*—In all parts of the world there is what may be termed the factors of general pressure and adaptability. In this should be included number of seeds produced or eggs laid, generations in year, powers of dispersal, competition and ability to find host or vacant space. In removal to a new country some of those factors may alter and thus lead to epidemic conditions. In the big land areas that pressure reaches its maximum. In the big variety of life present in such areas species are to be found which are capable of filling most nitches and others which will exercise direct destructive pressure upon most forms of life. The introduction of new species is least likely to succeed in such areas. They will find competition and enemies. It is in the more isolated and sparsely peopled, from a variety standpoint, portion of the world that introductions either harmful or beneficial most frequently run riot.

12. *Special protection.*—Many plants and insects possess special protection against general enemies. In plants, hairs, thorns, acrid, or bitter juices serve these purposes; whilst in insects, stings and acrid juices serve similar functions. As mentioned above also many insects live internally in fruits, flowers, roots and wood and such are most efficiently guarded against any but highly specialised foes. It is these protected species which so frequently cause trouble to agriculture and against which it is often so difficult to apply biological control methods. The banana scab moth larva living protected by the bracts of the bunch is only exposed to enemies for about four days as an egg and again during the pupal period. So that, in order to exercise any control, an enemy must attack it in the egg or newly hatched larval stage or again in the pupa, thus placing a definite limit to the amount of control likely to be obtained. This does not mean that the limit has been reached, predators may be found which will follow up, but against parasitic enemies and general predators this larva is well protected. So also are *Tirathaba*, the coconut spike moth and the banana borer, *Cosmopolites sordidus*. It will thus be seen that not only must a proposed introduction not attack any plant or insect of economic value, but when such has been found, and it may nowhere exist, it must possess ability to discover its host quickly or its numbers will remain too small to be of value. In Fiji, two parasites are known to attack the eggs of the banana scab moth, but probably through lack of mobility their value is negligible.

13. *Weed control.*—In weed control it must be remembered that cultivation will control all weeds, but such may not be economical. The factors which lead to the undue spread of a weed are, ease of distribution, longevity of seed and protection against general predators. In biological control of such weeds it is necessary to take every precaution that the proposed introduction is highly specialised as regards its host and, as I have mentioned elsewhere, to see, if the introduction is one which destroys the weeds, that the plant is quickly replaced by more useful herbage. To that end overstocking must be most carefully avoided.

AN INVESTIGATION OF THE BANANA-SCAB MOTH, NACOLEIA OCTASEMA, MEYR, AND ITS PARASITES, IN JAVA, AND THE INTRODUCTION OF ONE OF ITS PARASITES INTO FIJI.

By T. H. C. Taylor, M.Sc., Entomologist, Coconut Committee.

PART I.

A.—INVESTIGATIONS IN JAVA.

An investigation of *Nacoleia octasema* and its parasites in Java was made by the writer in 1932. The main object of this visit to Java was the study of the parasites of *Promecotheca nuciferæ* which mines in the coconut leaves, and comparatively little attention could be devoted to *Nacoleia*. Consequently, the notes which follow cannot be regarded as a complete statement of the problem. The investigation was confined to West Java, and although material was collected in a large number of localities, the bulk of it came from the neighbourhood of Buitenzorg and Batavia.

For advice and assistance, the writer is indebted to Dr. S. Leefmans, Director of the Instituut voor Plantenziekten, Buitenzorg, who did some work on this pest in 1915–16, and published a general account of it.* As a result of his experiments the Pyrethrum method of control has been satisfactorily used in Java for many years.

(*a*)—Nacoleia octasema.

Occurrence in West Java.—This pest was abundant in every locality visited, and present on every plant which had a suitable flower-spike, except in those places where control methods are practised.

Habits.—The habits of this insect do not appear to be quite the same in Java as in Fiji, and the observations here recorded apply only to Java.

Eggs.—The eggs are laid in small batches, and were most frequently found at the bases of the leaves, near to flower-spikes which are about to open. Much more rarely they were found on the large sheathing bracts of the flower-spikes. The number of eggs per batch averaged 15.

Larvæ.—There are five larval instars. On leaving the eggs, the young larvæ immediately make their way to the flowers, penetrating beneath the bracts. Since the eggs are laid on, or near, only those flower-spikes which have not yet begun to open, the young larvæ are never found on the fruit and the older larvæ very rarely. The normal food consists solely of flowers, not fruit, although in captivity larvæ of all ages will readily devour the skins of ripe fruit. When nothing else is available the larvæ will eat even badly decayed skins, and will produce normal moths in due course. The growth of the larvæ is very rapid, but is uniform and most rapid only when the food

* Mededeelingen van het Laboratorium voor Plantenziekten, No. 23, De Pisangmot.

is in the form of fresh flowers. Decayed flowers or skins greatly lengthen the larval period, and also increase the tendency to cannibalism, which occurs very frequently in captivity and probably in nature also.

As many as 70 large larvæ may be found in a single flower-spike.

Pupæ.—Pupation takes place inside a very scanty, silken cocoon. Pupæ and old pupal skins are to be found in large numbers underneath the old leaf bases which wrap round the stem throughout its length, and there is little doubt that this is the site normally chosen for pupation, though many pupæ are also to be found at or near the base of the stem underneath dead leaves on the ground.

Adults.—The adult moths energe from the pupæ between 8.0 and 9.0 p.m. The sexes occur in equal numbers. Copulation occasionally occurs on the night of emergence, but the majority do not pair till the following night, that is, approximately 24 hours after emergence. Oviposition usually begins on the night after that on which copulation took place, and is continued on the next night. As a rule oviposition takes place on two nights only, and the females die towards the end of the next day, the post-oviposition period being about 18 hours. Thus the normal duration of adult life is nearly four days, but occasionally oviposition is extended to three nights and in such cases the adult life covers five days.

In the course of bulk-breeding work, the number of eggs laid by each of 130 females was recorded. The maximum recorded was 194, but the great majority laid between 80 and 120. The average egg capacity worked out at approximately 110.

The moths feed readily on diluted honey.

Life cycle.—The duration of the early stages was determined accurately in December, 1932. Twenty larvæ were put in separate tubes with food as soon as they left the eggs, and were kept in those tubes throughout their development, fresh food being provided every day, regularly. The food consisted solely of fresh skins of ripe fruit. The results may be summarised as follows:—

Period.	Range (days).	Mean (days).	
Incubation	3·5 to 4·0	3·6	
1st Larval Instar ..	2·3 ,, 2·6	2·5	
2nd ,, ..	2·4 ,, 2·7	2·5	
3rd ,, ..	1·5 ,, 2·5	2·0	Total larval period = 16·5 (mean).
4th ,, ..	2·4 ,, 3·1	2·7	
5th ,, ..	4·5 ,, 7·0	5·5	
Prepupal	1·0 ,, 1·5	1·3	
Pupal	8·0 ,, 9·0	8·1	
Total (oviposition to emergence) . ..	26·1 ,, 30·1	27·7	

At the same time an experiment was made to ascertain the rate of development when the larvæ were fed on flowers instead of skins. The conditions were exactly the same, apart from the food, and 20 larvæ were used. The duration of each larval instar was not recorded in this case, only the total larval period (including the short prepupal period) being noted. The results for the 20 individuals were:—

Period.	Range (days).	Mean (days).
Incubation	3·5 to 4·0	3·6
Larval	11·0 to 12·5	11·5
Pupal	none	8·0
Total (oviposition to emergence)	23·0 to 24·0	23·4

The total duration of the life cycle was therefore shorter by approximately four days, and was also much more uniform, when the food consisted of flowers. The difference was wholly in the larval stage. Since flowers are the normal food in the field, the periods in the second table must be regarded as typical; but in the laboratory it was found much more convenient for bulk-breeding purposes, to use banana skins rather than flowers (except for very young larvæ), and therefore the first table was used as a basis for the routine, and the observations made were more detailed.

Method adopted for bulk-breeding.—The bulk-breeding of this pest, for the purpose of breeding its parasites, proved a very simple matter. The apparatus consisted of—

(*a*) two cages with gauze sides and top, and a capacity of approximately one cubic foot;

(*b*) six flat wooden boxes (14 in. by 14 in. by 3 in.) with wire gauze tops and bottoms, removable lids, and short legs, the latter enabling air to circulate through the boxes, in order to prevent the banana skins, which are placed inside, from becoming too wet when they begin to decay. The lower half of each box was divided into two compartments by a partition 1½ in. high, and skins (only) of bananas were placed on one side and dry soil on the other;

(*c*) a plentiful supply of glass tubes (4 in. by 1 in.).

A large number of pupæ of *N. octasema* was maintained in one of the cages, and food for the moths which emerged therefrom was provided in the form of honey or sugar in water. Ten ♂♂ and 10 ♀♀ were removed every day and put in the other cage, where they remained for one night, and were then removed, the ♀♀ being placed in glass tubes, one per tube, with food, and the ♂♂ discarded. The ♀♀ invariably oviposited on the glass (not in the cotton-wool bungs), and on the day when the black heads of the larvæ became visible in the egg batches, two banana flowers were inserted into each tube. Sixty per cent. of the ♀♀, on the average, were found to have paired, their eggs being fertile, and each paired ♀ laid ± 100 eggs, usually in two or three batches.

On the fifth day after the hatching of the eggs the tubes were emptied into the boxes. Approximately 200 larvæ and a plentiful supply of banana skins were put into each box, lumpy soil being placed on the other side. When the larvæ were ready to pupate they crossed to that side of the box containing the soil and made their cocoons amongst the lumps. It was found that ± 200 larvæ produced ± 180 pupæ, and the pupæ were removed to the cage as required.

If no soil is placed in the boxes, a very heavy loss results from cannibalism, the larvæ eating the prepupæ and pupæ. When soil is provided, cannibalism is negligible, since the feeding larvæ remain on one side of the partition and those ready to pupate go to the other side. The idea of using soil to prevent cannibalism in an insect which does not normally need soil was copied from the method devised by Mr. R. W. Paine, who used similar boxes, for the breeding of *Tirathaba*.

(*b*) PARASITES.

Parasitic enemies of *N. octasema* are very rare in Java. No egg or pupal parasites were found. A few eggs from which parasites had already emerged were noticed in one large batch, but the identity of the parasite was never discovered. No trace of pupal parasites was ever found, although there is little doubt that some of those pupal parasites which have a variety of hosts must occasionally attack this species, despite the fact that the pupæ are always hidden to some extent.

Three species of larval parasites were found, but all were surprisingly rare. These were a Bethylid (*Goniozus sp.*), a Braconid (*Apanteles sp.*), and an Ichneumonid (*Cremastus sp.*).* Their rarity implies that they have other hosts, and attack *N. octasema* only occasionally. Indeed, in the case of *Cremastus sp.*, an alternative (and much more frequent) host was found, while *Goniozus sp.*, being a Bethylid, can be expected to attack a great variety of lepidopterous larvæ. Some idea of the scarcity of these parasites can be obtained from the fact that out of the first 1,000 larvæ of *N. octasema* (all ages) collected in the field in five different localities, only two were parasitised by the Bethylid, seven by the Braconid, and six by the Ichneumonid. No accurate counts were made subsequently, but the parasites were never found more commonly. It is quite certain that parasites exercise no appreciable control on this pest in Java.

The scarcity of larval parasites must be attributed in part to the inaccessibility of the very young larvæ, the majority of which are inside flower-spikes which have not yet opened. A parasite could enter such flower-spikes only through a small hole or gap which often exists at the base of one or more of the covering bracts. No parasite of the size of any of those yet known could push its way between adjacent bracts, as the larvæ of *N. octasema* can. By the time when the spike opens most of the larvæ are usually too old to be attacked by the Braconid or the Ichneumonid, though they are not too old for the Bethylid.

None of the parasites was ever found in the pupal or adult stage in the field, and nothing is known about secondary parasites.

(1) *Goniozus sp.* (*Bethylidæ*).—This insect was bred for one generation only in captivity. The female oviposits on third-instar larvæ. When in search of larvæ it pushes its way very energetically into the masses of frass and silk which surround them. It frequently feeds on the larvæ, killing them by doing so. Oviposition is a tedious process. It is preceded by the paralysing of the host. The host mandibles are paralysed first, the parasite stinging the underside of the head and so rendering the mandibles harmless to it. Stinging in other parts of the body follows, at long intervals, the whole process occupying more than an hour. Eventually eggs are laid singly and transversely on the back between the segments, several eggs (3 to 5) on one host. The larva is not permanently paralysed, but recovers, and even resumes feeding, soon after the parasite ceases ovipositing. The larva continues to behave apparently normally for three days (and sometimes nearly four days) after it is attacked by the parasite, but it then spins a small and scanty cocoon, in which it remains inactive. The hatching of the eggs of the parasite usually coincides approximately with the spinning of the cocoon, the incubation period being 2¾ to 3 days. The parasite larvæ feed externally and grow with great rapidity, being full-grown, and completely devouring the host except for its skins, within three days. The host dies within its

* Specimens of all these parasites were sent to the Imperial Institute of Entomology, but only the Generic names have so far been received.

cocoon about 24 hours after the parasite larvæ have begun feeding. Having devoured all the available food the parasite immediately begin constructing cocoons inside that of the host. Their cocoons are cream-coloured, ovoid, and nearly opaque, and are completed in about 10 hours. They are closely packed together. Excretion takes place inside the cocoon and causes that end of the cocoon to look dirty. The cocoons of males are much smaller than those of females, and there is usually one male per host. The adults of both sexes emerge from the pupæ at the same time, but do not emerge from their cocoons for a considerable period which varies, in the case of the females, from one to 2½ days, and is usually at least two days. The behaviour of the male during this time is remarkable. It emerges from its own cocoon about one day after emerging from the pupa, but does not leave the host cocoon. Instead, on escaping from its own cocoon by biting a ragged hole, it immediately bites a similar hole in one of the female cocoons and crawls inside. It remains inside for an hour or more, and subsequently enters each of the other female cocoons in turn. Often it goes from one cocoon to the next, when all are in close contact, without coming outside at all. There is little doubt that copulation occurs during this procedure. The females leave the host cocoon as soon as they have emerged from their own.

The habits of this parasite, though remarkable, are not abnormal for *Bethylidæ*. The life cycle may be summarised as follows:—

Incubation period	2¾ to 3 days.
Larval period	2½ to 3 ,,
Period in cocoon (♀)	7½ to 9 ,,
Total (oviposition to emergence from cocoon)	13 to 15 ,,

(2) *Apanteles sp.* (*Braconidæ*).—The habits of this species of *Apanteles* require only a brief reference, being perfectly normal for those members of the genus which have external ovipositors and lay only one egg in each host. It oviposits very readily in captivity and was reared for six generations in captivity in glass tubes.

The adults emerge from their cocoons early in the morning, and pairing occurs on the day of emergence or at any subsequent time. The preoviposition period is very short, oviposition commencing on the day following emergence. The eggs are laid in very young larvæ of *N. octasema* (1st and 2nd instar), one per larva, and the females appear to be able to recognise larvæ which have already been attacked and to avoid them, with the result that superparasitism does not occur. The females can be induced to oviposit in 3rd instar larvæ, but only with difficulty. Only one egg is laid in each host. The stimulus for oviposition is provided by the frass and silken threads produced by the larvæ rather than by the larvæ themselves. The larvæ are unaffected by the sting of the parasite except at the moment of stinging, when they wriggle very energetically in attempting to escape. They continue feeding normally afterwards. Parasitised larvæ grow much more slowly than healthy ones, but moult at least once and usually twice before being killed. When they reach their maximum size they are much smaller than healthy larvæ of the same instar. Before being killed by the contained parasite, every host larva spins a flimsy cocoon. On the day after the formation of the host cocoon the parasite larva leaves its host by making a hole in its side. At this time the host contents have not yet been completely consumed and the host is not quite dead, but the *Apanteles* larva immediately proceeds to devour the remainder of the contents, except the skin, by feeding on it from the outside. This external feeding period is very brief, rarely lasting more than two hours. As soon as the host is completely emptied the parasite proceeds to construct a white cocoon, of typical *Apanteles* form, inside that of its host, and in this it pupates.

The period that elapses between oviposition and the emergence of the resulting parasite larva from the host varies from 9 to 12 days when the host is fed on fresh banana flowers. When the food consists of skins, the period spent inside the host may be longer. This period is such that in a batch of larvæ of uniform age, of which some are attacked by *Apanteles* when in the 2nd instar, the healthy larvæ spin their cocoons approximately two days after the parasites have emerged from the others.*

The normal life cycle is as follows:—

Period spent in host (egg + larva)	9 to 12 days.
Period spent in cocoon (prepupa + pupa) ..	6 days for males.
	7 days for females.
Total (oviposition to emergence)	15 to 18 days.

The sexes occurred in approximately equal numbers in the laboratory, but it is possible that parthenogenesis was responsible for an abnormal abundance of males. Unpaired females oviposit very readily, and invariably produce males only. The adult life covers at least four weeks, and the females oviposit every day throughout their lives when constantly supplied with a limited number of larvæ, except for a brief post-oviposition period of one, or at most two, days. An attempt to determine the egg capacity for 10 females gave a minimum figure of 47 and a maximum of 65, assuming that only one egg was laid in each of the larvæ which subsequently proved to have been attacked.

(3) *Cremastus sp.* (*Ichneumonidæ*).—This is an internal parasite which oviposits in 1st, 2nd, and early 3rd instar larvæ of *N. octasema*, but never in larger larvæ. The habits are very similar to those of *Apanteles sp.* to which reference has already been made. The adult parasite, when ovipositing, continually thrusts its long, external, ovipositor into the masses of frass and silk, in which the larvæ are concealed, and it rarely rests from this operation during the daytime. It is unable to recognise larvæ which have already been attacked, and frequently one larva is attacked several times. Only one parasite can develop in each host larva, and those larvæ attacked more than once usually die soon afterwards, their death being due, not to the number of parasites inside them, but simply to the mangling of their bodies by the extremely vicious thrusts of the ovipositor. Not infrequently, larvæ attacked only once die from this cause. Except at the moment when they are pierced by the ovipositor, larvæ are unaffected by the stinging. They resume their normal activities soon afterwards, and moult at least once and usually twice before the contained parasites emerge from them and kill them. The effect upon the growth of the host, and the maximum size reached by it relative to healthy larvæ of the same instar, are the same as in the case of *Apanteles sp.* But the rate of growth of the parasite within the host is rather slower than that of *Apanteles sp.*, so that whereas *Apanteles* larvæ emerge from their hosts (when the latter are stung in the 2nd instar) before the healthy larvæ of the same age make their cocoons, *Cremastus* larvæ do not, on the average, emerge from their hosts until the time when the healthy larvæ make their cocoons, or later. The host larvæ, although still small, invariably make flimsy cocoons when they cease feeding, and the parasite larvæ emerge two days later, and immediately begin making their own cocoons inside those of the hosts. No external feeding period was observed. The cocoon of the parasite is brown closely woven, and opaque. The parasite emerges by biting a ragged hole at one end of the cocoon, and always does so in the early morning.

* Larvæ fed on flowers.

When the host larvæ are fed on banana flowers, the life cycle of this parasite is as follows:—

Period spent in host (egg + larva) ..	11 to 12 days.
Period spent in cocoon (prepupa + pupa) ..	10 days.
Total (oviposition to emergence)	21 to 23 days.

When the host larvæ are fed on banana skins, partially decayed, the development of the parasites within them is very much slower, and the total period (oviposition to emergence) may be extended to as much as 36 days.

Reproduction in this species is solely by parthenogenesis, which produces females only. The species was bred continuously and in large numbers for 13 months in Java, and only one male* appeared. This male was very lethargic compared with the females, and although given ample opportunity in suitable conditions it did not show the slightest indication to pair, even when the females were ovipositing, and died when only seven days old. In any case there is no doubt that males are entirely unnecessary and quite abnormal. Only females emerged from material collected in the field.

The females live several weeks when kept in large glass tubes and fed with honey very slightly diluted. The maximum record for the adult life was 48 days, and nearly all females live at least three weeks. Oviposition begins, as a rule, on the day following that on which the female emerged from the cocoon and, having begun, every female can continue to lay eggs uniformly, at the rate of at least two per day, for the whole of its life, except for a short post-oviposition period not exceeding three days in duration. At least 20 eggs may be laid in one day by a female which has not been provided with larvæ for several days previously. An attempt to estimate the egg capacity gave unreliable results because many larvæ died from excessive stinging in the tubes in which they were enclosed with the parasites, but since the figure obtained for every one of the 10 females used in the experiment exceeded 50, while the maximum figure was 71, it is probable that the average egg capacity exceeds 70.

Cremastus sp. was reared in large numbers in glass tubes (6 in. by 1 in.) in Java. Ten young larvæ of *Nacoleia* and one parasite were put in each tube, with food for both, and left for two days. The parasite was then removed and a piece of banana skin inserted. After six more days, by which time the healthy larvæ were much larger than those parasitised, the large larvæ were removed and discarded. The parasitised larvae and the parasites themselves made their cocoons in the tube in due course. The yield of parasites by this method was not high, averaging only four per tube. Cannibalism was almost eliminated by removing the larger larvæ, but a considerable loss resulted from the death of many larvæ when they were stung by the parasites. Certainly this method, though convenient for experimental purposes, and for shipment, is too laborious to be recommended for bulk breeding.

It is important to note that *N. octasema* is not the most usual host for this parasite in Java. The only alternative host found was a Tinæid moth, not yet determined, and this was attacked far more frequently. The very young larvæ of this moth tunnel inside the large sheathing bracts of the flower-spikes, the bracts often being riddled by them. Later, they leave the bracts and construct tough, black, cases, greatly flattened, and in these they live and grow, and eventually pupate. They feed during this time chiefly upon the flowers, but they also feed externally upon the bracts, and they thrive in wet, decayed, accumulations of fallen flowers or fruit or any other part of the

* Since this specimen was preserved intact, nothing is known as to the condition of its internal organs, which may not have been typically male.

flower-spike. *Cremastus sp.* contructs its cocoons inside the case of the Tinæid, and the adult parasite emerges, not through the aperture for the anterior end of the larva at the end of the case, but through a hole which it bites in the sides of the case. This Tinæid was used to some extent for breeding *Cremastus sp.* in the laboratory.

B.—SELECTION OF CREMASTUS SP., AND SHIPMENT.

It was decided after a careful consideration of all aspects of the problem, that either *Cremastus sp.* or *Apanteles sp.* could be introduced with perfect safety into Fiji, and that although the prospects of either of them effecting an appreciable check upon the pest seemed very poor, the experiment was worth making. *Goniozus sp.* was ruled out as being likely to have too great a variety of hosts and unlikely to frequent bananas particularly or to show any preference for any one host. The chief reason for the improbability of either of the other two parasites being effective is that the young larvæ of *N. octasema* are probably too inaccessible to be attacked in large numbers. There is, however, a remote chance that a much higher percentage parasitism could be reached in Fiji because, firstly, alternative hosts may be absent, and secondly, the pest itself, whose habits do not appear to be quite the same in Fiji as in Java, may deposit its eggs later relative to the opening of the flower-spikes and so render its larvæ more readily accessible.

In the writer's opinion, a parasite attacking the large larvæ would be far more useful than any other, but no such parasite occurs in West Java, and probably not in any part of Java. Therefore, if a parasite of the large larvæ is required a search must be made elsewhere.

There was very little evidence to indicate which of the two parasites, *Cremastus sp.* or *Apanteles sp.*, was the more suitable for introduction into Fiji. *Cremastus sp.*, however, has a much longer ovipositor and can therefore penetrate more deeply into the banana flowers. Also in *Cremastus sp.*, reproduction is entirely parthenogenetic, while in *Apanteles sp.* parthenogenesis produces only males and pairing is therefore essential; and since there appears to be no wide difference between the two insects as regards egg capacity and duration of life cycle, the parthenogenetic *Cremastus* is potentially capable of more rapid multiplication. For these reasons, a decision was made in favour of *Cremastus sp.*

In view of the ease with which *Cremastus sp.* was bred in Java, and of the fact that a large shipment of parasites of *Promecotheca* was to be made at the same time, only a small shipment of *Cremastus sp.* was attempted. This consisted of approximately 100 cocoons and 50 adults, and in addition about 50 pupæ of *N. octasema* were shipped at the same time with the intention of obtaining eggs and larvæ of the pest on board and starting another generation of the parasite. But these plans were partially frustrated by the complete failure of *N. octasema* to pair at sea, despite the fact that the methods and apparatus employed were the same as those used so successfully in Java. It therefore seemed that the shipment depended solely upon the adults brought from Java, the cocoons having produced adults a few days out from Batavia. However, a call at Rabaul, New Britain, made possible the collection of about 60 young larvæ of *N. octasema*, and these were given immediately to the parasites, in tubes. But the results from these were very poor. Nearly all of them died very soon, presumably on account of excessive stinging by the parasites, which by then were very eager to oviposit. Of those which remained alive, only three proved to be parasitised. Fortunately, the parasites shipped in Java as adults and cocoons lived several weeks; and eventu-

ally 20 adults, all more than three weeks old, and the three parasitised larvæ, were handed over to the Government Entomologist in Fiji. The shipment left Java on April 17th, 1933, and reached Suva, after transhipment at Noumea, on May 16th.

Note.—It is interesting to note that *Apanteles tirathabæ*, a common parasite of *Tirathaba*, attacked *N. octasema* larvæ very readily in captivity in Java, though it never does in nature. The adults were bred out in due course. The failure of this parasite to attack *N. octasema* in nature is probably due solely to the fact that it is a coconut-frequenting species.

A. tirathabæ was introduced into Fiji in 1930 as an enemy of *Tirathaba*.

PART II.

BREEDING WORK IN FIJI.

By H. W. Simmonds, F.E.S., Government Entomologist.

Mr. Taylor reports the presence of three parasites of this moth in Java, an Ichneumonid (*Cremastus sp.*), a Bethylid, and an Apanteles. All were extremely rare insects, in fact the writer himself when in Java bred some 500 adults of the moth without meeting either species.

2. It was decided to attempt the introduction of the *Cremastus* and a breeding technique for both host and parasite was worked out. Unfortunately so far as the host was concerned this broke down *en route* to Fiji and only the survivors from Javanese hosts and two pupæ which Mr. Taylor was able to rear from a few larvæ obtained in Rabaul reached Fiji. These survivors numbered twenty-four, one of which escaped from a perforated tube, leaving twenty-three adults and the two pupæ. Only one of these latter emerged, which gave a breeding stock of twenty-four, all in good condition and as the insects were all females, reproduction being parthenogenetic, ample, for the purpose, if not too senile.

3. *Early breeding in Fiji.*—In breeding the first generation in Fiji, the technique used in Java was carefully followed. This consisted of placing each female parasite in a tube with twenty second instar *Nacoleia* larvæ and leaving it there twenty-four hours. Whilst this leads to considerable superparasitism and numerous deaths of the host larvæ, no great improvement has been obtained by other methods so far. Trials have been made of ten larvæ changed twice or three times in the twenty-four hours, with, however, little result.

4. *Deaths of imported material.*—The first death amongst the imported stock occurred four days after landing and by the end of a month only five survived and these were showing signs of senility. None the less one remained alive another two weeks. The Rabaul bred one died at the fourteenth day, probably due to accidental injury.

5. *Hosts.*—The technique evolved for the Javanese *Nacoleia* did not prove quite so successful in Fiji and certain differences in behaviour were noticed. Fewer eggs were obtained per moth, although improved methods of feeding later gave better results. Another difference observed in comparing notes with Mr. Taylor was that the Fijian form generally oviposits on the leaves surrounding the spike whilst the Javanese form uses the spike sheath for this purpose. This entails a longer journey for the newly hatched Fijian larva to its food than the Javanese larva has to undergo and during

this period it will be exposed to attack by the *Cremastus*. In both cases, however, the young larva so quickly obtains the protection of the covering sheath as to render it doubtful if any larval parasite is likely greatly to reduce its numbers.

6. *Suva breeding work.*—Working on the lines mentioned above the first Suva parasite emerged from its host and pupated on May 30th, a larval duration of 12–13 days. By June 12th two hundred parasite pupæ had been obtained and it is estimated that the total number of adults of the first generation in Fiji will be about 350 from the twenty-four parents.

7. In the cooler climate of Fiji all stages of the parasite lengthened out and became somewhat irregular whilst, curiously, it was found that the adults were not ready to oviposit until the fourth or fifth day, instead of within twenty-four hours as in Java and this may be due to the same cause.

8. Various modifications of the breeding technique were attempted and the most satisfactory so far has proved to be using the tubes for ovipositing and placing all larvæ into small cages with abundant food. Two weeks after parasiting this cage is removed to a large one where it is opened daily, when all adult parasites fly to the sides and are easily collected.

9. At the commencement of July a fresh system was adopted in which all breeding tubes were coloured in sets of six. The parasites were only used on alternate days. In this way twelve breeding adults in separate tubes could be allotted to each day and the different colours dated with the date of the emergence of the parasite so that a regular replacement of breeding parasites became possible as the insects grew older, the age of each individual being known. Changes are being made every fifth day, which with two sets of ten females gives an allowance of 25 days for each to be used.

10. *First generation in Fiji.*—As stated the first adults emerged on June 12th and by the end of that week the number had reached ninety-one. There was much uneveness in the pupal period, possibly due to the cold weather experienced at the time, a variation between ten and sixteen days for this stage being noted. There was also some mortality in this stage, possibly due to this same cause. This can be tested out when warm conditions prevail. It is estimated that the first generation raised locally from the imported parasites will exceed 350. Of the fourteen adults which emerged on the 12th seven were withdrawn for breeding purposes and these commenced ovipositing on the 16th, being four days from emergence to ovipositing. They were not, however, very interested and it was not until the seventh day that they showed a keen interest in their work. Owing to the considerable period between emergence and ovipositing it was deemed advisable to retain the adults in tubes and feed them for a few days before liberating in order to reduce accidental mortality to a minimum before they had a chance to find their hosts.

11. *Liberation.*—The first liberations were made on the 20th at Colo-i-Suva and Tamavua 4-miles, when 35 and 27 females were released at the respective spots. The weather unfortunately was dull and rather cold.

12. Further liberations up to date have brought the number released up to 540. As reproduction is parthenogenetic the male being unknown, each female forms a colony in herself and it is not necessary to release in big numbers to ensure mating. By this means it has been possible to scatter the insect rapidly, but as such scattering means small numbers in any one place it may be some time before any recoveries are made in the field.

COCONUT AND OTHER OIL-BEARING PRODUCTS.

(Extract from *The Times of Ceylon Mail Edition*, February 27th, 1933.)

THE useful commodity reports issued from time to time by the Empire Marketing Board are valuable in setting out the facts relating to any particular industry in true perspective. We are generally apt to exaggerate the importance of any trade with which we are concerned and the part that our own particular country plays in that trade. In dispelling some of these erroneous impressions, the Board provides at the same time valuable information for the use of the active and intelligent producer. Many in Ceylon are inclined to regard copra as being of greater importance than any of the oil-bearing products that are in competition with it. In volume of production, however, soya beans hold pride of place, slightly preceding cotton seed, with all the others some distance behind. In regard to actual oil content, there is, however, little to choose between soya beans, cotton seed and ground nuts, with copra, owing to its high oil yield, not far behind. From the point of view of gross revenue to the producer, soya beans are stated to be in the aggregate about 50 per cent. more valuable than either cotton seed or ground nuts, which in turn are nearly double the value of linseed, copra or olive oil. But the aggregate value of the whole of the vegetable oil-seed group, together with olive and palm oils, would, on the basis of United Kingdom import values in 1926–30, be of the order of only about £700,000,000, which is barely one-half the value of the world's wheat crop computed in the same manner, and is probably less in value than the total output of butter. Important as the oil-bearing plants are, and rapidly as they are increasing, they do not yet approach in value any of the world's leading farm products. It has to be borne in mind that the market for fatty oils is not by any means confined to vegetable sources for its supply. The whale and several kinds of fish also yield oil which falls very definitely within the group, while over a wide area there is direct competition between oils of this kind and such animal fats as butter, lard and tallow. As regards copra, of which Ceylon is an important exporter, the Dutch East Indies are the largest exporting unit with the Philippines and British Malaya competing for second place. Ceylon being a poor fourth. The figures given for 1931 are 354,000 tons from the Dutch East Indies, 188,000 tons from British Malaya, 171,000 tons from the Philippines and 94,000 tons from Ceylon. In addition to exporting copra, these countries are exporters also of coconut oil. The Philippines export an average of 146,000 tons of coconut oil, equivalent to 230,000 tons of copra; the Dutch East Indies 17,000 tons, equivalent to 27,000 tons of copra; and Ceylon 37,000 tons equivalent to nearly 60,000 tons of copra. If these be included in the figures of copra exports the Philippines are about level with the Dutch East Indies in their contribution to world supplies over the five years, while Ceylon's exports are greater than the net exports from British Malaya. A large proportion of British Malaya's exports consist of re-exports, her net exports of copra being little greater than those of Ceylon. The United Kingdom draws its copra supplies from many different sources, but generally Empire

countries furnish from two-thirds to three-quarters of the total. The Dutch East Indies are the chief foreign source of supply, and some proportion of the imports credited to British Malaya may also come from the Dutch East Indies. Direct consignments from that quarter have increased in late years, and in 1929 and 1930 those islands constituted the most important source of United Kingdom copra supplies. Provisional figures for 1931 show United Kingdom imports from Dutch East Indies amounting to 31,000 tons and from British Malaya totalling 13,000 tons. Ceylon is represented by only 1,000 tons—her trade being smaller than that of Fiji or of the British West Indies. It would thus seem that the United Kingdom policy of Imperial Preference should tend to divert the trade from the Dutch East Indies, there being ample scope for Ceylon particularly to increase her proportion. While the Empire Marketing Board supplies comprehensive analyses of the position of the Empire as a producer and consumer in regard to each product, an extension of this system of examination seems called for as a result of the policy of Imperial Preference. It seems desirable that each unit of the Empire should be surveyed with particular reference to its part in the Preference arrangement. Such a survey of Australia, for instance, would be extremely useful as showing her interchange of trade with Java and with Ceylon, and its bearing upon the preferences accorded by both Australia and Ceylon. The Board, of course, has territorial production surveys, but these do not show in sufficient detail the interchange of trade between individual Empire territories and between Empire units and foreign countries. It is important that careful note should be taken of any change in trade resulting from the adoption of Preference.

BULBAR PARALYSIS IN A BULL IN QUARANTINE.

By C. R. Turbet, B.V.Sc., Senior Veterinary Officer.

The occurrence in the Animal Quarantine Station of a case of Bulbar Paralysis in an imported Hereford bull is thought of sufficient interest to record. The bull was imported from New South Wales along with five others, arriving in Suva on the evening of 6th May. The health papers of these animals were in order. They were landed and dipped between 6 p.m. and 8.15 p.m. the same day. One bull was noticed to be lame at the time, but it was too dark to see detail. On the following day the bull was found to be exhibiting an obscure lameness which appeared to affect the off fore and near hind legs more than the other limbs. At this time no great importance was attached to the lameness, it being considered as merely due to sore feet brought on by the sea voyage. The bull was isolated and the four healthy bulls allowed into a separate paddock. (The sixth bull was also isolated owing to an injury to the eye resulting in a most acute ulcerating interstitial keratitis with pannus. This required treatment.)

Subsequent observations on the sick bull were as follows:—

Monday 8th.—Bull not interested in food and disinclined to move about. He appeared lame diagonally when made to move about.

9th.—Lameness was not improved. On driving the bull a slight staggering gait was observed with a slight swaying of the hindquarters. Also a slight protrusion of the tongue and dropping of saliva was noticed. The bull was handled but no cause for lameness was discovered.

10th and 11th.—No change was noticed in the condition of the bull. He was not noticed to graze or drink.

BULBAR PARALYSIS IN A BULL IN QUARANTINE.

12th.—The bull was lying when visited but readily got up and moved off with a staggering gait. The lameness was now seen to be not so much a true lameness as a condition of incoordination of movement. The temperature was taken and found to be 101 ° F. The protrusion of the tongue was seen to be a constant symptom, together with the dropping of saliva. A few faint coughs occurred.

13th.—Temperature, 101 ° F. General weakness was seen to be increased.

14th.—The ribs were observed to be fixed with respiration weak and of abdominal type. A scurfiness of the skin was noticed. Urine discharged normally.

15th.—Grass stalks were observed protruding from the mouth, the tongue was lolling out. It could be retracted but not turned up to lick the lips and nostrils as in the normal. On being disturbed the retraction movements of the tongue would be increased, but on allowing the beast to settle down the tongue would come to rest fully protruded to about five inches. The mucuous membrane of the tongue appeared anæmic. Saliva was continually dropping. On examining the mouth a large wad of food about eight inches long by four inches wide and one inch thick was found lying in the pharynx along the posterior part of the dorsum of the tongue. This consisted of unmasticated grass in the anterior portion and of oaten chaff in the posterior, the whole impacted into a moulded mass. This was removed by hand and the hand pressed back through the pharynx and the larynx examined. This was found to be rigid. The œsophageal opening was firmly closed and the fingers were introduced with difficulty. An impression of paralysis of the region was gained.

On examining the chest wall no respiratory sounds could be obtained. The heart's action was unusually slow and weak.

Up to this time no diagnosis had been made, but the condition was seen to be such as would be caused by a paralysis of certain cranial nerves, principally the 9th to the 12th. Some aspects of the case caused traumatic pericarditis, tuberculosis and contagious bovine pleuro pneumonia to be considered, and since these latter two were of the utmost importance from the point of view of animal quarantine and disease prevention, some concern was felt.

16th.—The condition of the bull was so bad that after consultation with interested parties it was decided to destroy the animal. Before doing so however, a definite diagnosis on clinical grounds was made after comparing the symptoms with those described by Seddon in his article " Bulbar Paralysis in Cattle due to the action of a Toxicogenic Bacillus with a discussion on the relationship of the condition to Forage Poisoning (Botulism)," published in the *Journal of Comparative Pathology and Therapeutics*, Volume XXXV, No. 3, September, 1922. Since this disease is non-contagious the cause for alarm was removed.

The animal was slaughtered on 17th. Before slaughter the bull was photographed to enable a record of identity and general appearance to be kept. The photograph shows the general debility of the animal, protruding tongue, eyes closed, devitalized condition of the skin as suggested by the folds of the brisket seen in front of and behind the elbow, leaning of the hindquarters towards the left which suggests a staggering gait when moving.

On autopsy, a small amount of grass was found in the pharynx. No recently eaten grass was found in the rumen, the content of which consisted solely of chaff. No chaff had been fed since the landing from the " Rona "

on the 6th, thus eleven days had passed since the animal had last eaten, and the date of the infection must have been before the 6th. Since the slight lameness noticed on landing must be considered as an early manifestation of the disease, the infection probably occurred about 3rd or 4th whilst on shipboard. The most likely source of infection would be the chaff. The amount of infective food must have been small however, since none of the other animals have shown any sign of the disease, yet all received similar fodder.

The omasumal content consisted of chaff in a partially unmasticated state and the whole content of an unusually dry consistency. No other abnormalities were seen except some small encrysted nodules in the lungs containing pus of a yellowish green colour. These were taken to be old worm nests and were considered to be unrelated to the cause of the disease. The absence of gross pathological lesions found and the abnormalities mentioned are consistent with the diagnosis of Bulbar Paralysis. A specimen of bone was forwarded to the Government Bacteriologist for examination. No organisms were found.

It is unfortunate that the disease occurred in a valuable imported animal. From the point of view of the danger to health of cattle in Fiji, the disease is of practically no importance. It is of interest however in being the first recorded case of this disease in Fiji.

PLANTATION HORSE MANAGEMENT.*

By C. R. Turbet, B.V.Sc., Senior Veterinary Officer.

Incapacitated working horses on one's hands is an annoying business to plantation managers and others using working horses, not only on account of the loss of horse working-power but also in time and money spent in caring for them. It is much more satisfactory if horses can be maintained in good health.

2. Working horses on Pacific Island plantations are fortunately not subject to a large range of ailments. Strangles, that acute infectious disease of young horses in more temperate climates, does not seem to persist. In Fiji it has appeared for short periods following new importations, but soon totally disappears. The principal troubles met with are due to infection with worms of various kinds, attacks by flies, infestation with their larvæ and granulating tumour on the limbs and other body parts. The Fiji sore is a representative of this type of disease, whilst in the Solomons the so-called swamp cancer is probably identical. In addition to these diseases caused by contagion, injury due to pure accident, ill-fitting harness, or the friction of harness on emaciated bodies have varying degrees of incidence according to the lack of skill or care on the part of individuals or other local features.

3. Climatic conditions also affect the health of the horses, for instance, heavy and continuous rain devitalizes the skin of horses in poor condition whilst well-conditioned horses are little affected. Such conditions, of heavy continuous rain are common in some Pacific Island territories, particularly in the so-called wet season. Heat apoplexy may be encountered due to working animals too severely on hot days, or when the sun is high. The condition is not seen so much in coconut plantations where the animals would usually work in shade as on sugar plantations where such shade does not exist.

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4. The feeding of plantation horses is not a very complex business and the foodstuffs are usually limited to those available locally. A normal horse on fair average pasture not being worked will usually appear well conditioned and with sleek coat. Such a horse is not, however, fit for hard continuous work immediately but should be brought into work gradually.

5. Unless pasture of particularly high quality exists and the horses are given ample time for grazing, supplementary feeding is essential if working horses are to remain in good condition. Fodders available for supplementary feeding are usually chopped grasses, such as Para grass, Guinea grass or cane tops. Concentrate if it can be obtained should also be fed. One of the most suitable and easily obtained is maize. This is best fed cracked either alone or with chopped stuff in rations of from two to ten pounds per day, according to the size of the horse and the work which it has to perform. Coconut meal and good quality rice bran are also excellent feeds and might be fed in quantities of three pounds of coconut meal to six pounds of rice bran for working horses. The dry bran should be mixed with the coconut meal which has been soaked with water, so that a slightly moist meal is produced. The actual quantity to be fed is best judged by trial. This list practically completes the list of available foods except in sugar growing districts where molasses can easily be obtained. The most universal and useful fodder is undoubtedly maize which can be grown well in most island territories. No mention is made of imported fodders which are usually too costly to be economically used.

6. Work by horses should as far as possible be done in the cooler parts of the day. When working on transport it can usually be arranged that the horse works two shifts such as from sunrise to 10 a.m. and from 3 p.m. to sunset. If working on cultivation it is preferable to start even earlier, say, 5 a.m. and work through till 11 a.m. and then finish for the day. It is folly to work horses longer in the tropics.

7. Referring again to disease conditions, almost all horses will become worm infested and according to the severity of the infestation and the age of the horse the ravages of the disease become manifest. Aged horses on good pasture maintain their condition. Young animals or horses on poor feed lose condition in varying degree. In Fiji probably the chief cause of mortality of horses is infestation with one of these worms (*Strongylus vulgaris*) which as an adult lives in the large intestine, but in its developmental stage passes part of its time in the anterior mesenteric artery, the large artery which divides into numerous smaller ones to supply the intestines. In this location it produces an inflammation of the wall of the artery leading to hardening, hæmorrhage and in some cases even rupture of the artery wall. As a result of this condition horses develop colic through stoppage of the blood supply to parts of the intestines, sometimes sudden death through rupture of the artery, or death through blockage of arteries by blood clots blocking the passage. Other worms cause anæmia through robbing the blood supply of the host. Horses therefore should be periodically treated for worms. Before treatment they should receive 24 hours starvation, water alone being allowed. They should then be given a drench consisting of turpentine, 1 oz., oil of chenopodium, $\frac{1}{2}$ oz., raw linseed oil, 1 pint; or, 2 oz. carbon tetrachloride in a solution of $\frac{1}{2}$ lb magnesium sulphate in a pint of water. This should be kept well shaken while it is being administered to keep the insoluble tetrachloride in suspension. A third drench is carbon-tetrachloride 2 oz., oil of chenopodium $\frac{1}{2}$ oz., liquid paraffin $\frac{1}{2}$ pint. The latter is rather more expensive.

8. Sharp edged teeth or other irregularities are sometimes responsible for poor condition. Periodical examination of the mouth and the use of tooth rasp is therefore sometimes indicated.

9. The well known ulcerating granulating tumours such as Fiji Sores (or swamp cancer) are caused by the infection of small wounds with a fungus known as sporotrichon. This fungus is found outside the animal's body in moist places rich in organic matter, particularly of animal origin. Some localities are known to be much more heavily infected than others. Stables can be freed of the infection by a removal of contaminated organic matter, such as old manure or manure-fouled mud and subsequent treatment with disinfectants, such as sheep-dip or chloride of lime. Where swampy fields are known to be infected great care should be taken of any wounds which might occur and in some cases it might even be advisable to keep the animals off such pasture.

10. The careful treatment of wounds is in fact of primary importance in the control of these tumours. Almost in all cases they occur at the site of an accidental wounding of the skin. Normally the intact skin is very resistant to infection. Animals working in localities where the disease is prevalent should be examined daily for wounds. Should any of serious extent be found below the knee or hock the animals should be kept away from wet or muddy places. The hair should be clipped or better, shaved from the area surrounding the wound. The suturing or stitching of wounds is not advisable unless the person responsible is confident that the wound can be maintained free from germ infection. If that can be done then a sutured wound will do well. If not the suture holes will suppurate and the stitches pull through, resulting in the wound again breaking open. In the meantime suppuration has been going on within the wound enclosed by the sutures. It will be seen therefore that if the chances of a wound remaining uninfected with germs is not good it is better to leave it open or unstitched. Practically all open wounds will heal well, leaving suprisingly little sear, provided no foreign body is included and the wound is carefully cleansed at least twice daily with an antiseptic solution of correct strength. In addition, the wound must be protected from flies. This point is most important. The application three times daily of the following dressing will be found efficacious in keeping flies off the wound:—Olive, peanut, cotton seed or coconut oil 8 oz., turpentine 2 oz. and creosote 3 drachms. The best manner in which to wash wounds is to play a stream of antiseptic lotion on to and within the wound if deep, using an ordinary rubber enema syringe with a nozzle at one end and a bulb in the centre. The following antiseptic solution will be found satisfactory:—(*a*) Large quantities of common salt solution made by dissolving a teaspoonful to the pint or a handful to a bucket of boiled and cooled water; (*b*) lysol solution; (*c*) cyllin solution 1 part to 100 of water; (*d*) Cooper's sheep-dip 1/100; (*e*) Eusol made by mixing together equal parts of boric acid and fresh chloride of lime and adding two ounces of the mixture to half a gallon of water in a large corked bottle (Winchester bottle). This should be allowed to stand overnight and then the clear supernatant fluid syphoned off or poured off into a second bottle. The disinfectant value of this solution depends chiefly on its chlorine content. Since this is not stable it is soon lost. Eusol should not therefore be kept but should be remade about every three days when a wound is being treated. A wound irrigated twice daily with good Eusol will heal without interruption. All open wounds heal by throwing out granulation tissue. During the healing should any granulations appear excessive, by overlapping of the edges of the wound or by rising

above the level of the skin surface, such granulations should be checked by carefully and lightly touching the offending granulations only, with a crystal of blue stone.

11. Old chronic Fiji Sores are difficult to treat but if treatment is adopted early on the appearance of one of these tumours, chances of recovery are good.

12. In the early stages a Fiji Sore may appear simply as an excessively granulating wound, but the change from day to day is small. It does not tend to heal and after a time it will be noticed to be increasing in size. Besides the infection with the fungus causing the disease there is always an infection of the surface of the sore with pus forming germs which aggravate the condition. Treatment should be both surgical and by drugs. According to the shape of the sore, whether it has a wide base or a narrow one it may be treated by burning with a fire iron or it may be excised with a sharp knife. This operation should not be attempted unless the operator has some surgical knowledge and it is possible to give an anæsthetic such as chloroform. After being cauterized or excised with a knife it should be treated as an ordinary wound with the addition of tincture of iodine as a dressing. The wound will require bandaging after the excision to help to stop hæmorrhage and keep out immediate reinfection. Old standing sores may be treated by washing thoroughly with antiseptic solutions to kill surface organisms and then a daily dusting with blue stone powdered or the smearing of the surface with a blue stone ointment. This treatment should have the effect of greatly reducing the size of the sore. The application of the previously mentioned anti-fly dressing daily is necessary to protect the sore from flies. Standing in salt water has also been found beneficial. Potassium iodide given internally is a specific drug for the treatment of this condition. Unless a cheap supply can be obtained, however, its high cost prohibits its use. The dose is from 2 to 5 teaspoonfuls administered daily in drinking water or as a drench. It should be continued daily until the animal commences to lose condition and the skin exhibits a harshness with scaling of the skin cells. The administration of the drug should then be stopped until the animal again recovers condition. Biniodide of mercury being cheaper may be given as an alternative drug combined with potassium iodide as follows:—Biniodide of mercury 5 drachms, potassium iodide 5 drachms, water 3 pints. One ounce of this solution should be given three times daily either in the water or mixed with food.

13. As mentioned before the treatment of old Fiji Sores is difficult and tedious. Prevention of them, on the other hand, or the treatment of those in the early stage is not difficult. The keeping of the legs as dry as possible will help towards this end. Plantation managers and others responsible for the maintenance of health of plantation horses should therefore be on constant guard to detect the early formation of these tumours and to adopt remedial measures early.

PRACTICAL SEED SELECTION OF COCONUTS.

(With acknowledgements to the *Malayan Agricultural Journal*, June, 1933.)

By A. C. Smith.

In the past the selection of seed for the planting of the main commercial areas of tall coconuts in Malaya appears to have been carried out on what, at the best, must be termed haphazard lines. This grants that, in most cases, planters have done their utmost with existing facilities to obtain the best planting material on offer.

In no branch of agriculture is good seed expensive, be times good or bad, and this is particularly the case with perennial crops with a long economic life—coconuts for example which normally remain profitable for a period of 30 to 60 years. In a crop of this nature planting is done once and for all, the use of poor material cannot be rectified in the following year as is the case with annual crops. The planter must stand upon the seed he provides in the first instance, therefore the expenditure of a few dollars more per acre on the best possible material is of little moment. Expressed in terms of cash one looks upon the difference between seed cost of $5 and $25 per acre on a 1,000 acre estate as vast, but if by provision of improved seed, yields can be obtained only 10 per cent. above average, say from 10 to 11 piculs of copra per acre, the cost plus interest is fully recouped in 7 or 8 years—less than one quarter of the economic life of the palm—even with copra at $5 per picul.

Three methods of seed selection appear to have been used on the European owned coconut areas of Malaya—

(1) in the older (pre-1900) plantings, by purchase from any mature estates or kampongs which had some reputation for yields and which were so situated as to afford reasonably cheap transport;

(2) by mass collection from known high yielding estates or areas;

(3) in a few cases from selected heavy cropping palms in known high yielding areas.

Each method marks a definite step forward but it cannot be said that great progress has been made. It cannot be denied that in respect of this problem the coconut industry lags behind most other large scale tropical products. Rubber, a much newer commercial agricultural proposition, has made enormous strides during the past 10–12 years, whereas coconuts have practically nothing to record. The reason for this is undoubtedly the time involved in evolving and proving a pure strain—probably two generations or about 25 years. There is unfortunately, no short cut by vegetative propagation as in the case of rubber, but as coconuts have been established as a commercial proposition for upwards of thirty years in Malaya, the industry should by now be far ahead of where it actually is, and it must be admitted that very little energy has been applied to this most important yield factor.

Of the methods enumerated above, (2) is that most frequently used but at best it can only be expected to provide plants which will return good average yields. Examination of any high yielding area will establish the fact that the variation in yield per palm is from 0 to over 120 nuts per annum, with more than 50 per cent. of palms below average.

(3) is an improvement upon (2) but in most cases selection is confined to palms carrying heavy heads of nuts without due regard to copra content. Even where selection is carried a step further to handling and opening nuts from such palms for inspection of meat content, the margin of error is very large. Detailed examination of ripe nuts from 47 palms, all with a wet meat content of over 600 grammes, showed a variation in meat thickness between 10·5 and 15·5 mm. with the main group lying between 12·5 and 13·5 mm. Inspection of two nuts of approximately equal size with meat thickness of 12·5 and 13·5 mm. will indicate the difficulty of judging meat content by casual observation, yet the difference is no less than 8 per cent. An increase or decrease of 1 mm., although it has a very large bearing upon copra yield, is almost impossible to detect by eye alone.

Very detailed examination of palms and their nuts for seed purposes is, although laborious, well within the capabilities of any planter, and it requires no scientific training or special plant. From the writer's experience 600—700 palms can be examined and possibles marked in two to two and a half hours, and this is about as much as should be attempted at any one time; it is very tiring and one's power of observation flags towards the end. Where an area of palms returning yields well above average is available on an estate, the advantages of taking seed from such an area for extensions or replanting are manifest. The primary advantage is that environmental conditions are suitable, palms doing well on one part of an estate should do well elsewhere in the same area, assuming that there is no great difference in soil and drainage conditions. There is no guarantee that seed from high yielding palms on the free undulating soils of say Penang Island would do equally well on the flat alluvial clays of the Lower Perak District.

If seed is required for a small area, close selection is a simple matter, but, if a clearing no larger than 100 acres is to be planted, it will be necessary to scour a fairly wide area to obtain a sufficient quantity of the required standard. Seedings are usually planted out fairly early in the rainy season, and to obtain sturdy plants of even growth at this time necessitates the laying down of seed for the whole area more or less simultaneously. There is undoubtedly a tendency towards economising in the number of seed nuts purchased or laid down, and in consequence one frequently notices that the last portion of a clearing contains a proportion of poor and weakly seedlings. The total seed laid down should not fall far short of 100 per cent. in excess of the number of plants required. For 100 acres planted 30 ft. by 30 ft. and, allowing for first supplying, 5,000 plants are required: 9,000 seed is none too many. With germination of 85 per cent. which is rarely exceeded, the margin is only some 2,500 plants, or in other words two in every three have to fulfil ideal conditions as regards growth. Using seed from palms yielding not less than 100 nuts per annum with a satisfactory copra content, not more than 35 suitable nuts will be obtained from each palm during the three heaviest cropping months. This necessitates not less than 250 selected parent palms, and as such palms, even in a very high yielding area, only amount to 3—5 per cent. of the whole stand, it entails the examination of 6,000—7,000 palms, or an area of 120—150 acres. If planting can be spread over a whole year it should be possible to obtain an average of about 150 nuts per acre from the selected area, or sufficient to plant up rather more than 1½ acres per acre of the selected area.

No method of seed selection which has to contend with open pollination, and consequent hybridisation, can be described as ideal, but so far there is no available supply of seed coconuts of pure strain, at least not on the scale applicable to estate requirements when planting up large areas. Work of this nature is now being carried out by Officers of the Department of Agriculture at the Klang Experimental Station, but it will be long before a pure line is evolved and proved, two generations of coconuts or about 25 years, and then in all probability seed will not be available in large quantities. Beyond the fact that under normal conditions the tall coconut rarely if ever "selfs," and that therefore all seed must be cross pollinated, little is known of its genetics and hereditary traits. The best that can be done is to commence with an area containing a large percentage of palms yielding well above average, the chances of fertilisation from a high yielding parent being distinctly favourable. The methods adopted by the writer and described below should be the most satisfactory in the light of present knowledge and applicable on a commercial scale. Selection method (2)

is fully complied with in that the area from which seed is taken return yields far above average, and (3) is fulfilled by the close examination of individual palms, thus as far as possible ensuring good female stock.

Selected area.—80 acres.

Age.—27 years. Planted 1906.

Planting.—30 ft. by 30 ft. = 48 palms per acre.

Yields.—Average 13 years 1920—1932, 3,860 nuts per acre. Conversion approximately 235 nuts per picul copra = 16·3 piculs per acre. Actual stand of bearing palms 45·5 per acre = 82 nuts per palm.

Situation.—All mature areas within approximately half mile radius return average yields of 3,300—3,500 nuts per acre.

Soil.—Flat alluvial clay.

Total palms examined.—3,875. Vacancies, supplies and non-bearers 153, bearing palms 3,722.

Method of selection.—Only palms carrying 100 nuts or more are selected as possible parents, all ripe nuts are collected from such palms and one typical specimen is selected for examination and weighing of wet meat.

DETAILS OF PALMS.

Total examined	.. .. ..	3,875	
,, 100 nuts and over	.. ..	690	= 17·8 per cent.
,, 50 nuts and under	.. ..	1,109	= 28·6 ,,
Average of "100 nuts" palms	..	117·23 nuts	

Having thus arrived at exceptionally high yielding palms as regards number of nuts, the selected nut from each was then weighed for wet meat content. The following table gives the weight outturns in grammes wet meat per nut:

Table I.

Over 700 grammes	.. ..	3	= 0·4 per cent.
600/700 ,,	.. ..	47	= 6·8 ,,
500/600 ,,	.. ..	191	= 27·7 ,,
400/500 ,,	.. ..	307	= 44·5 ,,
300/400 ,,	.. ..	128	= 18·6 ,,
Under 300 ,,	.. ..	14	= 2·0 ,,
		690	100·0 per cent.

These figures necessarily refer only to the 690 selected palms. That there would have been nuts from the palms carrying under 100 nuts returning both larger and smaller wet meat yields cannot be doubted. They further emphasise that the proportion of really high grade palms in a very high yielding area is very small, and that mass seed collection from such areas is unsound. Only 241 palms of the 3,875 examined returned 100 nuts of 500 grammes or more wet meat, equal to 6 per cent. In any system of close selection one would never go below 500 grammes.

The general yield of estate grade copra is 50 per cent.—53 per cent. of the wet meat content of nuts dealt with. Taking the lower figure, the approximate number of nuts required per picul of copra from the several categories is therefore:—

(453·59 grammes = 1 lb. 60,479 grammes = 1 picul = 133·33 lb.)

700 grammes	.. ..	= 173 nuts per picul.
600 ,,	.. ..	= 201 ,,
500 ,,	.. ..	= 242 ,,
400 ,,	.. ..	= 302 ,,
300 ,,	.. ..	= 403 ,,

A small variation in size will be found in nuts from the same palm and even from the same bunch. One nut cannot therefore be taken as a definite determination but it is the best that can be done under normal estate conditions, and if care is taken in selection, is accurate within practical limits.

The selection of nuts on wet meat content merely denotes working to a standard, dependent almost entirely upon the area available for selection and the number of seed required. If a large clearing is to be planted up, it will probably be necessary to modify the standard; if a very small area, selection can be very close and high grade planting material can be secured. In the writer's case two small clearings totalling only 15 acres were planted with nothing under 575 gramme seed, but where nuts were supplied for a 50 acres clearing in one delivery the standard had to be scaled down to 500 grammes.

It is frequently asserted that nuts of pronounced ovoidal shape should not be used as seed. Details of shape of the whole 690 nuts were recorded and it was found that there was no practical difference in meat content between oval and round specimens. Neither did colour appear to have any bearing upon the value of the nut. Red, yellow and green types all show more or less the same percentage of good and poor yielders and high and low meat contents.

Further points emerged when approximately 500 nuts from 66 palms, all over 575 grammes, were laid down in the nursery. Wide variations in germination and growth were to be expected and careful notes were kept of the behaviour of seed from each palm. These were of such interest that a second batch was laid down as a check. In almost every case the general characteristics of seed from the same mother palm were identical in both batches. The first lot was laid down in July and notes taken in November, after four months. The second batch was laid down in November and notes taken in February, also after four months. Weather conditions in each case were favourable to germination and growth. The following examples of results from the two batches may be taken as typical of the whole:—

Palm No. 12. 631 gr.	November 8 nuts.	Germination 8=100 per cent. all strong healthy plants.
	February 8 ,,	Germination 7=87 per cent. All strong even plants.
Palm No. 29. 588 gr.	November 10 nuts.	Germination 7=70 per cent. Weak and irregular, only 2 good.
	February 14 ,,	Germination 13=93 per cent. Very slow and weak, only 4 fair.
Palm No. 37. 575 gr.	November 10 nuts.	Germination 10=100 per cent. All strong even plants.
	February 25 ,,	Germination 24=96 per cent. All strong even plants.
Palm No. 51. 656 gr.	November 14 nuts.	Germination 9=65 per cent. No good plants, irregular and poor.
	February 9 ,,	Germination 1=11 per cent. Useless.

Palm No. 88. 585 gr.	November	10 nuts.	Germination 10=100 per cent. All poor plants with malformed shoots.
	February	8 „	Germination 5=62 per cent. Poor, all shoots malformed.
Palm No. 122. 575 gr.	November	7 nuts.	Germination 4=60 per cent. Weak, irregular and poor.
	February	10 „	Germination 6=60 per cent. Weak, irregular and poor.
Palm No. 160. 630 gr.	November	18 nuts.	Germination 9=50 per cent. All very poor plants.
	February	8 „	Germination 2=25 per cent. All very poor plants.
Palm No. 183. 588 gr.	November	12 nuts.	Germination 12=100 per cent. Exceptionally strong even plants.
	February	8 „	Germination 8=100 per cent. Very good and even.
Palm No. 190. 594 gr.	November	8 nuts.	Germination 4=50 per cent. Poor.
	February	4 „	Germination 1=25 per cent. Useless.
Palm No. 239. 605 gr.	November	2 nuts.	Germination 2=100 per cent. Both malformed shoots.
	February	12 „	Germination 10=83 per cent. 7 malformed shoots.

On the whole, the large nuts showed a small percentage of germination and less strong healthy plants than did those of more nearly average size. There was very little difference in total germination percentage between the two lots, and in each case almost exactly 60 per cent. good sturdy even plants were obtained after five and four and a half months respectively. This indicates that it is unsafe to lay down less than 80 per cent.—90 per cent. seed in excess of actual requirements.

The data recorded in the foregoing shows that there is room for vast improvement in yields by careful seed selection provided that the female parental characteristics are transmitted in the majority of cases. As stated previously, little is known regarding this at present but at the worst one commences with female stock of high standard, and with the male parent also taken from a high yielding area, chances are greatly in favour of better yields than have hitherto been attained. Returns of over 15 piculs of copra per acre are now deemed almost phenomenal, yet with promiscuous seed supply a large area is capable of yielding over 16 piculs per acre for 13 years. This is undoubtedly due largely to environmental conditions but it indicates that potentialities are greatly in excess of standards hitherto accepted as high, if close seed selection is carried out in an area of this yielding capacity. Even if environment is rather less favourable, selection on these lines should outweigh this, and similar yields, which are much above average, should be obtainable from any area of good coconut land with reasonable drainage facilities and good cultivation. Under approximately similar environmental conditions, with selection no closer than palms yielding 100 nuts per annum with a 550 grammes wet meat content, yields of over 20 piculs per acre should be attainable. (5,000 nuts per acre at 220 nuts per picul.) Of the 3,875 palms examined 123, or slightly over 3 per cent., reached this standard—1½ palms per acre. Any high

yielding area,—3,500 nuts per acre or better—should return approximately similar figures, therefore, as noted earlier, each acre should be capable of providing seed for about 1½ acres new planting each year. This by no means exhausts potentialities. Odd palms consistently returning over 800 grammes wet meat are met with. One in particular has so far averaged over 900 grammes and yields 70—80 nuts per annum or half a picul of copra from a relatively low nut output. The largest nut handled gave over 1,100 grammes wet meat, which equals 100 nuts per picul.

CONCLUSIONS.

(1) By seed selection it should be possible to increase copra output per acre to a figure considerably in excess of that now accepted as normal.

(2) Examination of possible parent palms must cover both number of nuts and copra yield per nut. Also, having obtained seed of the required standard it is necessary to study nursery results in view of the fact that certain palms persistently yield nuts of low germination percentage and poor growth characteristics. Seed from high yielding palms is useless if it refuses to germinate, or having done so, produces progeny unfit to plant.

(3) Close selection of seed calls for nothing which cannot be carried out in ordinary estate practice, and is a simple matter on estates which contain areas of high yielding palms.

(4) With the standard scaled down to 100 nuts of 500 grammes palms, under 20 piculs per acre, only 6 per cent. of palms in a given area are fit for selection as mother palms.

(5) In the light of (4) mass seed collection from the best known areas can only be termed crude and haphazard.

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OMISSION.

The Entomologist regrets that, in compiling the list of insects introduced into Fiji published in Vol. 5, No. 1, he omitted to acknowledge the assistance given by the Imperial Institute of Entomology at Farnham Royal, who collected and forwarded the colony of *Mesembrina* mentioned in that list.